

The Learning Factory: A Didactic Platform for Knowledge Transfer in South Africa

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Abstract

During the first years of their employment, the graduates are a liability to industry. The employer goes an extra mile to bridge the gap between university-exiting and profitable employment of engineering graduates. Unfortunately some cannot take this risk. Given this scenario, this paper presents a learning factory approach as a platform for the application of knowledge so as to develop the required engineering competences in South African engineering graduates before they enter the labour market. It spells out the components of a Stellenbosch University Learning Factory geared towards production of engineering graduates with the required industrial skills. It elaborates on the didactics embedded in the learning factory environment, tailor-made to produce engineers who can productively contribute to the growth of the industry upon exiting the university.

Keywords

Learning factory, university graduates, competences, didactics, industry

1 INTRODUCTION

South Africa, as an emerging economy relies generally on the manufacturing sector for its growth. The industries which make this sector get their top-brass workers from the universities. Upon employing them, they find that some university graduates are still raw. They are unproductive during their early period of employment. Some of the graduates receive a cultural shock from the work environment in industry. They are simply a liability during the early phases of their employment, which at times deters some industries from promptly engaging university graduates upon exiting the university. Industry at times goes an extra mile to train them so that they reach a level on which they would be productive. However, not all industries are forthcoming to take up this burden. They would rather employ an experienced person than newly graduated university students. Therefore, the paper postulates a solution to this problem by presenting a Stellenbosch University Learning Factory (SULF) as a viable solution within the South African context. It reveals the competences required by industry on university graduates as they join the labour market. It also reveals some expected outcomes of Engineering Council of South Africa (ECSA) upon university graduates. Furthermore, the paper elaborates how the gap between industry and university may be mitigated by a learning factory approach in the educating of students.

2 LEARNING FACTORY APPROACH

Special skill requirements, demanded by industry and ECSA, require special use of appropriate teaching and learning methods, which meet specific

training objectives in the fields of planning, implementation and optimization of production and manufacturing systems. Overall, there is a growing interest in practical and experiential learning environments. As a result, leading universities and colleges react by establishing learning factories [1-4].

These physical, operational factories usually cover the whole creation process of a product selected in accordance with didactical criteria and serve as exemplary and realistic hands-on learning environments. The concept of learning factories integrates self-directed and action-oriented learning in heterogeneous groups to encourage experiential knowledge, integrated into a formal didactical concept. This enables the trainer to address the intended competences systematically by guiding the learners through the processes necessary to acquire the intended knowledge and professional and/or vocational competencies. This symbiotic combination of the teaching of professional expertise, methods, individual competencies and soft skills [5, 6] may be achieved by combining traditional, instructor-based teaching methods with hands-on sessions held in teamwork to improve social and group work competencies. The tasks or problems students get confronted with are inspired by issues of high practical relevance and designed openly to avoid predefined solutions or approaches. By using mostly commercially available technologies in learning factories, a very authentic learning environment may be created, resulting in a highly immersive learning experience for the learners [7]. Additionally, high learning success is achieved by including the self-actions of and the interactions

between the learners into the learning experience [4, 8].

Hence, the learning factory approach is seen as a didactical approach of learning which aims at producing graduates who have competences required in a real working environment [9]. These competences are acquired by students when exposed to real or simulated working environment during their university education [9].

2.1 Resources in a Learning factory environment

For a learning factory to produce the required calibre of graduates it should have a competent personnel (who may be lecturers, engineers and technicians). These should be able to interpret the requirements of industry and translate them into objectives of their specific modules and then create the appropriate content of study. They should be competent enough to communicate effectively those objectives to the students and be able to convey, using an appropriate methodology, the contents during the teaching period. A real work environment similar to an industrial set-up should be availed to university students to experiment in, as has been established in the case of Ruhr University, Darmstadt University [9] and Reutlingen University. The environment may be a physical room with the necessary equipment used in a real industrial set-up. In the case where such is not possible to achieve, a simulated environment may be a viable option. Videos of the real world of industry may also be used and video conference between students and engineers in their working environment as in the case of Greece [10].

2.2 Didactics in a learning factory

Learning involves mainly two parties: the students/trainees and the educators/facilitators. The educators (in this case include lecturers, practising engineers, technologists and technicians) facilitate the learning of the students and industry's trainees in a learning environment. They facilitate in the sense that they expose the students and trainees to the learning factory modules (or subjects) and then allow them to methodologically apply the concepts in a hands-on session within a real industrial environment or simulated environment. In this learning factory environment, the lecturer does not use a teacher-centred approach to learning [11], but rather a student centred approach [11] in which the students or trainees empirically apply the knowledge obtained from the theoretical contents of the modules to a pseudo or real world environment at a level higher than simply doing an experiment in a laboratory. In some cases the students are given open-ended tasks without predefined solutions to allow them to develop the critical competences required in industry. Learning factories add flair to the learning environment by affording a "trial and error playing field" in which students and trainees

may sharpen their competences by attempting to solve problems of industrial nature within the university premises [12].

3 SOUTH AFRICAN INDUSTRY AND ECSA REQUIREMENTS FOR LEARNING FACTORIES

3.1 ECSA Requirements

Generally the requirements of South African industry on university graduates are enshrined in the Engineering Council of South Africa (ECSA) outcomes and competences [13, 14]. These ECSA outcomes require university engineering graduates to have, among others, the following competences: problem solving capabilities, ability to apply scientific methods and tools to solve problems, capability to solve inter-disciplinary problems, capability to work independently, ability to work productively in teams, ability to solve as well as manage ambiguous and complex engineering problems [13, 14]. Although universities are trying to inculcate these competences in their students before existing the university, they are failing to adequately achieve this as revealed by some delegates who attended the South African Institute of Industrial Engineers Conference in 2013 (SAIIE 2013). The SAIIE 2013 delegates, during a discussion after an initial presentation on learning factory concepts, asserted that some engineering graduates are falling short as far as these competences are concerned, they even stated that some of them suffer a cultural shock, such that they are unproductive during the first period of their employment.

Currently, to improve the graduate engineers' competencies after leaving the university, South African companies have to train the graduates for some time to make them competent engineers. Normally the training is conducted under an ECSA registered mentor (a registered ECSA practising engineer). In some cases such training may take even more than two years. This paper proposes that the length of such training may be reduced if a learning factory approach is introduced at some point during the training of engineers.

3.2 Industry requirements for South African Learning Factories

In order to get the most benefit out of a Learning Factory; the taught competencies, processes and topics as well as the deployed infrastructure in the form of hard- and software have to be aligned with the requirements and needs of South African industry and academia. This alignment would at least partially bridge the mentioned gap between university and industry. Hence, approaching both parties before establishing a Learning Factory and developing learning modules is crucial.

3.2.1 Method

For this purpose, carrying out a workshop is an appropriate method of gathering special requirements for a South African Learning Factory. As in the case of the Stellenbosch University Learning Factory, such a workshop was carried out at a Conference of the International Academy for Production Engineering (CIRP) General Assembly which was held in Cape Town in 2015. In a four-hour workshop, participants from industry, academia and consulting were first introduced to the term 'Learning Factory' followed by an introduction into industrial engineering and its education in Learning Factories. On this theoretical base, two examples of Learning Factories were presented, the ESB Learning Factory of Reutlingen University and the Stellenbosch University Learning Factory which is currently in a developmental status. In order to tailor the Stellenbosch University Learning Factory to the needs of the local industry, specific requirements from industry were interrogated within a brainstorming session by posing three questions:

- Question 1: What are the most relevant topics to be covered in the Learning Factory?
- Question 2: What processes should be presented in the Learning Factory?
- Question 3: What technologies are relevant; which IT-systems have to be integrated in the Learning Factory?

The workshop closed with a panel discussion with reference to the stated questions.

3.2.2 Main results of the workshop

Operations management methods, such as lean management, process optimisation and change management; and soft skills such as communication, team work, project management, intercultural and leadership skills, were among the most mentioned topics to be taught in Stellenbosch University Learning Factory. Besides those two learning areas, smart factories: including both the digital world and human/machine interface were also identified as relevant learning topics for a South African Learning Factory. A small number of participants mentioned also advanced design, product lifecycle management and networks as other topics to be included.

The most remarkable response to the question concerning processes which should be presented in the Learning Factory was that the entire product lifecycle, from the digital design and simulations stage through real production and assembly processes, including logistics and recycling, should be integrated in an Learning Factory environment by using cloud engineering and manufacturing execution systems.

Concerning Information Technology (IT) and Technologies questions, answers were given in line

with relevant processes which can be realised and supported by IT. Software for designing and simulation, software for planning and controlling manufacturing and production as well as software for allocating human resources and managing projects were recommended to be integrated in an South African Learning Factory environment.

3.2.3 Way forward

As a way forward, the knowledge gained from the workshop would be transferred into learning concepts that form the base for the development of learning modules for students and industry's participants who would be trained at the Stellenbosch University Learning Factory. Synthesising the outcomes of the learning factory through the internal enterprise architecture in Figure 1, the Stellenbosch University Learning Factory would in its initial phase cover the areas highlighted in yellow.

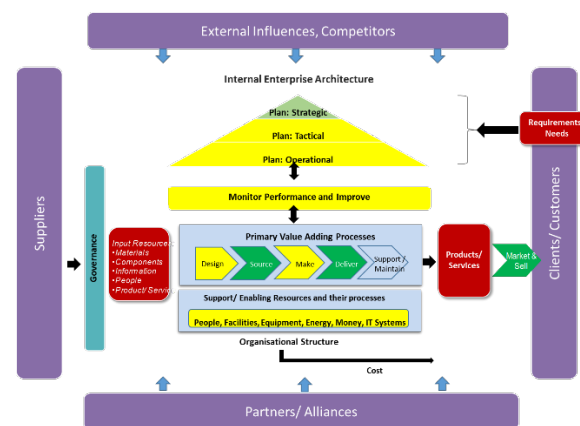


Figure 1 - Areas covered by Stellenbosch University Learning Factory

The Production Management modules would initially cover the operations management aspects (lean management, logistics, process optimisation and team work) the Quality Assurance module would cover aspects related to performance monitoring and improvement as well as product life cycle; Industrial ergonomics would cover aspects to do with the interaction among human resources, machines and the environment with respect to safety and ethical requirements. Manufacturing processes and Manufacturing systems would cover competences to do with design, production, assembly processes and simulation. Since a product is required in the morphology of a learning factory [15] alongside the learning modules, a collaboration with the Passenger Rail Agency of South Africa (PRASA) Research Chair has been initiated in which physical rail wagon models would be used in the Stellenbosch University Learning Factory.

With respect to the required ECSA competences [14] upon engineers, Table 1 shows a synthesis of some of the broad competencies engineering graduates are expected to have after undergoing Stellenbosch University Learning Factory environment.

Modules	Broad Competences
Production Management	Competency to manage complex engineering activities [14]
Manufacturing Processes and Manufacturing System	Competency to design and develop solutions to complex engineering problems [14]
Industrial Ergonomics	Competency to make ethical decisions [14]
Quality assurance	Competency to meet standards expected independently in employment or practice [14]

Table 1- Module Competences

Figure 2 shows the educational pyramid, revealing the gap a learning factory fills in the production of engineering graduates who are better geared for the working environment in industry. In a university set-up, normally students firstly attend lectures, secondly they do tutorials, thirdly they may do experiments in laboratories, and fourthly they should then be exposed to the learning factory before they exist the university as indicated in Figure 2.

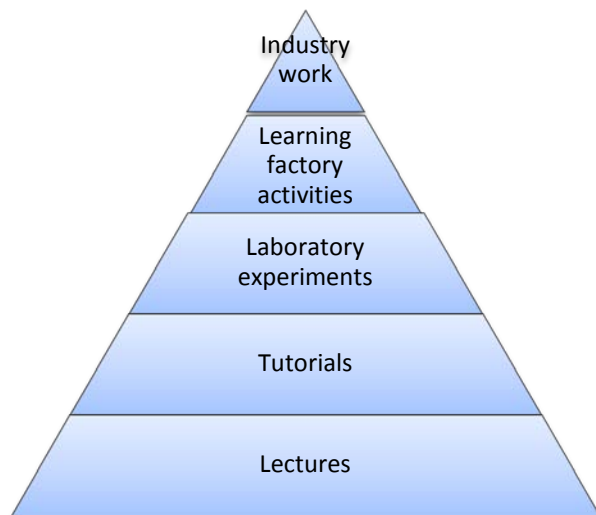


Figure 2- Learning factory - gap filling

In the learning factory environment, students attempt to solve a real world problem using a systematic, integrative approach applying various concepts they would have learnt in their learning-factory-tailor-made modules [12]. The problems could be holistic and complex in nature, not unidirectional – affording students various options as solutions, thereby necessitating the need to

brainstorm, analysing the problem before synthesising a solution. This affords them the opportunity to work as a team in solving multi-directional and multi-disciplinary problems by logically applying various concepts learnt in their modules and outside the module as they would have researched [12]. It should be noted that the methodology used to solve the problem is not merely an experimental approach under normal laboratory conditions, but rather at a higher level, in which a logical, systematic and integrative approach is applied in solving a real-world complex problem [9].

4 CONCLUSIONS

In conclusion, a learning factory is an environment in which students are exposed to a real-world or simulated environment in which they tackle real-life problems which might be multi-directional and interdisciplinary in nature so that they develop industry-required competences by experientially exploring solutions. From the CIRP Learning Factory's workshop inputs, Stellenbosch University Learning Factory would provide a similar environment so that its engineering graduates would acquire competencies to design and develop solutions for complex engineering problems as well as to manage complex engineering activities. By offering tailor-made learning modules, delivered by a learning factory approach, the competence gap between student capabilities and the industry's as well as ECSA's expectations in a South African context can be mitigated.

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6 BIOGRAPHY



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